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13. ABSTRACT *(Maximum 200 words)*

Research under this grant led to a number of new and promising developments in the use of signal processing methodology and algorithms—including multirate system theory—in the solution of wireless and related communication problems.

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Advanced Signal Processing Techniques for Wireless Communications

for the period

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Principal Investigator: Prof. Gregory W. Wornell

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Research under this grant led to a number of new and promising developments in the use of signal processing methodology and algorithms—including multirate system theory—in the solution of wireless and related communication problems.

In one component, we developed novel bandwidth-efficient temporal diversity strategies for single- and multi-user wireless communication in time-selective multipath fading environments. Both frequency selective and frequency nonselective channels were considered. These multiple-access protocols we referred to as spread-signature CDMA.

We also developed powerful new algorithms for equalization and demodulation in conventional and spread-signature CDMA wireless systems. These algorithms efficiently suppress both intersymbol and interuser (multiple-access) interference.

In other aspects of the research, we developed a closely related class of computation- and bandwidth-efficient techniques for exploiting spatial diversity at the transmitter in wireless systems, which are useful either alone or in conjunction with other forms of diversity.

Another component of the research program explored applications of nonlinear dynamics and chaos in the design of error-correcting codes for communications applications, and the use of fractal traffic models in the design and management of efficient, next-generation packet-switched communication networks. Still other work explored efficient iterative algorithms and performance limits for both single-user and packet-switched communications over channels with feedback.

All these results are described in detail in the following publications, which consist of journal articles, conference papers, technical reports, and student theses.

1. G. W. Wornell, "Spread-Signature CDMA: Efficient Multiuser Communication in the Presence of Fading," *IEEE Trans. Inform. Theory,* vol. 41, no. 5, pp. 1418–1438, Sept. 1995.

2. S. H. Isabelle and G. W. Wornell, "Statistical Analysis and Spectral Estimation Techniques for One-Dimensional Chaotic Signals," to appear in *IEEE Trans. Signal Processing,* submitted Aug. 1995. Accepted for publication Dec. 1996.

3. G. W. Wornell, "Efficient Multiuser Communication in the Presence of Fading," in *Proc. IEEE Int. Sympo. Inform. Theory,* (Whistler, Canada), Sept. 1995. (long presentation)

4. G. W. Wornell, "Spread-Response Precoding for Communication over Fading Channels," *IEEE Trans. Inform. Theory,* vol. 42, no. 2, pp. 488–501, Mar. 1996.

5. W. M. Lam and G. W. Wornell, "Multiscale Representation and Estimation of Fractal Point Processes," *IEEE Trans. Signal Processing,* vol. 43, no. 11, pp. 2606–2617, Nov. 1995.

6. G. W. Wornell, "Emerging Applications of Multirate Signal Processing and Wavelets in Digital Communications," in *Proc. IEEE,* Special Issue on Applications of Wavelets (invited paper), vol. 84, no. 4, pp. 586–603, Apr. 1996.

7. G. W. Wornell and M. D. Trott, "Efficient Signal Processing Techniques for Exploiting Transmit Antenna Diversity on Fading Channels," in *IEEE Trans. Signal Processing,* Special Issue on Signal Processing Advances in Communications, Jan. 1997.

8. G. W. Wornell and M. D. Trott, "Signal Processing Techniques for Efficient Use of Transmit Diversity in Wireless Communications," in *Proc. Int. Conf. Acoust., Speech, Signal Processing,* (Atlanta), May 1996. (invited paper)

9. W. M. Lam and G. W. Wornell, "Multiscale Analysis of Fractal Point Processes and Queues," in *Proc. Int. Conf. Acoust., Speech, Signal Processing,* (Atlanta), May 1996.

10. Chen, Brian, "Efficient Communication over Additive White Gaussian Noise and Intersymbol Interference Channels Using Chaotic Sequences," S.M. Thesis, MIT, Cambridge, MA, Feb. 1996. Also as RLE Technical Report No. 598, Research Laboratory of Electronics, MIT, Cambridge, MA, April 1996.

11. Beheshti, Soosan, "Techniques for Enhancing the Performance of Communication Systems Employing Spread-Response Precoding," S.M. Thesis, MIT, Cambridge, MA, Feb. 1996.

12. A. Narula, M. D. Trott, and G. W. Wornell, "Information-Theoretic Analysis of Multiple-Antenna Transmission Diversity for Fading Channels," in *Proc. Int. Symp. Inform. Theory and Appl.* (Victoria, Canada), Sept. 1996.

13. B. Chen and G. W. Wornell, "Efficient Channel Coding for Analog Sources using Chaotic Systems" in *Proc. IEEE GLOBECOM,* (London), Nov. 1996.

14. J. M. Ooi and G. W. Wornell, "Decentralized Control of a Multiple Access Broadcast Channel: Performance Bounds," in *Proc. Int. Conf. Dec. Control,* (Japan), Dec. 1996.

15. J. M. Ooi and G. W. Wornell, "Fast Iterative Coding Techniques for Feedback Channels," submitted Oct. 1996 to *IEEE Trans. Inform. Theory.* Also as RLE Technical Report No. 613, Research Laboratory of Electronics, MIT, Cambridge, MA, Dec. 1996.

16. A. Narula, M. D. Trott, and G. W. Wornell, "Information-Theoretic Analysis of Multiple-Antenna Transmission Diversity," submitted Nov. 1996 to *IEEE Trans. Inform. Theory,* Nov. 1996.

17. S. H. Isabelle and G. W. Wornell, "Recursive Multiuser Equalization for CDMA Systems in Fading Environments," in *Proc. Allerton Conf. Commun, Contr., Signal Processing,* (Illinois), Oct. 1996.

18. B. Chen and G. W. Wornell, "Analog Error-Correcting Codes based on Chaotic Dynamical Systems," submitted to *IEEE Trans. Commun.,* Dec. 1996.

19. S. Beheshti and G. W. Wornell, "Iterative Interference Cancellation and Decoding for Spread-Signature CDMA Systems," to appear in *Proc. Vehic. Tech. Conf.,* (Phoenix), May 1997.

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